

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

1
Ag 84F
cop 4

Control of Caterpillars on Cabbage and Other Cole Crops



UNITED STATES
DEPARTMENT OF
AGRICULTURE

FARMERS'
BULLETIN
NUMBER 2271

PREPARED BY
SCIENCE AND
EDUCATION
ADMINISTRATION

Contents

	Page
Caterpillars and How They Damage Plants . .	3
When and Where They Occur	14
Control with Insecticides	16
Selecting Insecticides	17
Applying Insecticides	21
Natural Controls	23
Cultural Controls	23
Safety Precautions	23

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

This bulletin supersedes Farmers' Bulletin No. 2099, "Control of Caterpillars On Commercial Cabbage and Other Cole Crops in the South."

Control of Caterpillars on Cabbage and Other Cole Crops

By C. S. Creighton¹ and J. E. Halfhill,²
SEA research entomologists

The feeding of caterpillars on cabbage and other cole crops reduces the income of growers by millions of dollars each year. The losses are accounted for in part by damaged or contaminated crops—lower yields and lower quality—and in part by the cost of combating these insects.

Cole crops other than cabbage that are attacked by caterpillars are broccoli, brussels sprouts, cauliflower, Chinese cabbage, collards, kale, and kohlrabi.

Caterpillars and How They Damage Plants

At least 18 kinds of caterpillars damage cole crops. They can be grouped according to their destructiveness:

1. *Those frequently causing major damage nationwide.*—These are the larvae of the cabbage looper, the imported cabbageworm, and the diamondback moth.

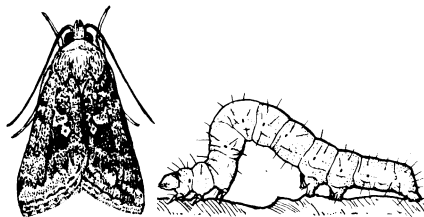
2. *Those causing serious damage in some areas.*—These are the larvae of the cabbage webworm, the cross-striped cabbageworm, the

earworm, and three species of armyworms and cutworms.

3. *Those causing only occasional or minor damage.*—These are the larvae of the alfalfa looper, the armyworm, the bertha armyworm, the southern cabbageworm, the Gulf white cabbageworm, and the salt-marsh caterpillar.

Cabbage Looper

The cabbage looper is considered to be the most destructive of the caterpillars attacking cole crops (fig. 1). It is the larva of a medium-sized, grayish-brown moth. The moths



TC-3851

Figure 1.—Adult and larva of the cabbage looper.

have a figure-eight-shaped silver spot near the middle of each of the front wings. The moths are most active at night and fly about at plant height while they are laying eggs or feeding. They have a wingspread of $1\frac{1}{4}$ to $1\frac{1}{2}$ inches (3.2 to 3.8 cm).

The moths lay their greenish-white eggs singly and mainly on the

¹ USDA/SEA, Vegetable Insects Research Laboratory, Charleston, S.C. 29407

² USDA/SEA, Vegetable and Field Crop Insects Research Laboratory, Yakima, Wash. 98902

lower surfaces of the outer leaves of the plants. The eggs are smaller than a pinhead, are ridged, and are almost round.

When first hatched, the larvae have dark heads and almost colorless bodies. They later become pale green and have several whitish, lengthwise stripes that fade considerably as the larvae grow. When mature, the larvae are about 1½ inches (3.8 cm) long. They crawl by doubling up, or forming a loop, and then projecting the front part of the body forward.

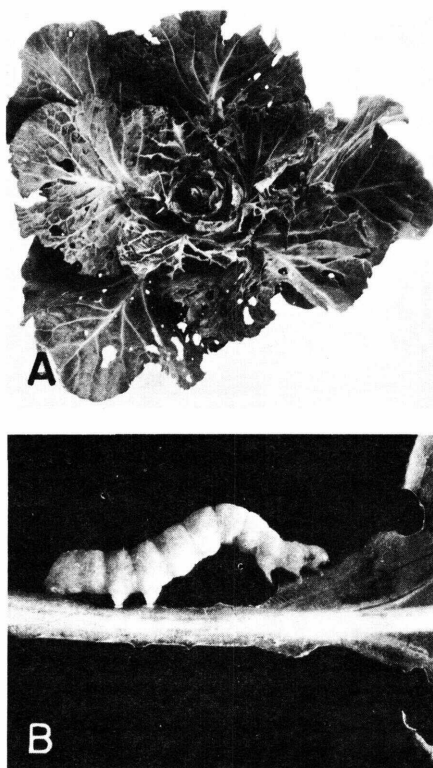
The pupae are pale green, copper, or dark brown, depending on their maturity. They are encased in loosely woven cocoons that are attached to a leaf or debris near the base of the plant.

Newly hatched larvae of the cabbage looper usually eat out small areas on the underside of plant leaves. As they grow, they move nearer to the center of the plant, eating through the leaves between the veins. The large larvae feed from the edge of the leaf inward (fig. 2).

Large larvae are heavy feeders and may cause serious damage to the marketable portions of the plants, especially if the larvae are numerous or the plants are immature. Damage, however, may be confined to the wrapper leaves or inedible portions of the plants.

Alfalfa Looper

The alfalfa looper damages cole crops, particularly broccoli and cauliflower, in western Washington and Oregon. This insect's life history and habits are similar to the cabbage looper's, except that in the Northwest it is a pest in the spring



TC-7009, TC-4012B

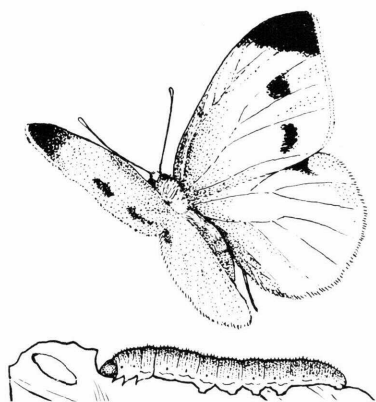
Figure 2.—Injury caused by cabbage loopers: A, Typical injury to center part of a cabbage plant. B, Full-grown looper feeding on a leaf. Note the characteristic notches along edges of the leaf.

and fall as well as in the summer. The larvae of the two species and the damage they cause are nearly indistinguishable, but the moths of the alfalfa looper can be distinguished from those of the cabbage looper by the "gamma"-shaped mark on the front wings, which are blue-gray rather than brown-gray.

Imported Cabbageworm

The imported cabbageworm is the larva of a yellowish-white butterfly (fig. 3). The butterflies have several black spots on their wings and a wingspread of about 1 inch (2.5 cm). They are frequently seen flying in and near plantings of cole crops.

The butterflies lay eggs singly on either side of the leaves of cole crops. The eggs are yellow, oblong, bluntly pointed at the ends, deeply ridged lengthwise, and attached to the leaf by one end.



TC-3851

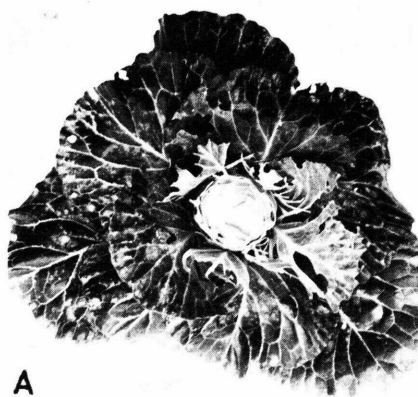
Figure 3.—Adult and larva of the imported cabbageworm.

The larvae are velvety green. They have a narrow orange stripe down the middle of the back and a yellowish stripe along each side of the body. When mature, the larvae are about 1 1/4 inches (3.2 cm) long. These larvae are sluggish when disturbed.

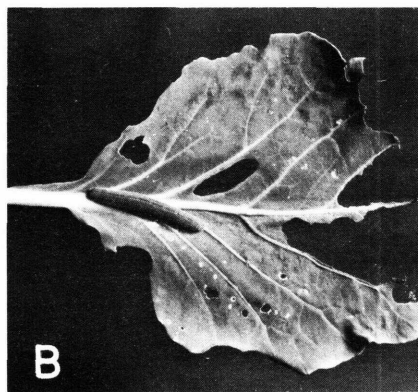
The pupae may be green, gray-green, or tan. They have sharp angular projections in front and along the back, and a tough covering. They are attached by a thread

resembling silk to a leaf of a host plant or to some other object in the field.

Imported cabbageworms cause injury similar to that of the cabbage looper, but they are more likely to feed nearer the center of the plant, and do more damage to the edible portions (fig. 4). When feeding, they do not restrict themselves to the areas between the veins but may feed through the leaf indiscriminately.



A



B

TC-4010, TC-9010

Figure 4.—Injury caused by imported cabbageworm: A, Typical injury to center part of a cabbage plant. B, Imported cabbageworm on leaf.

Diamondback Moth

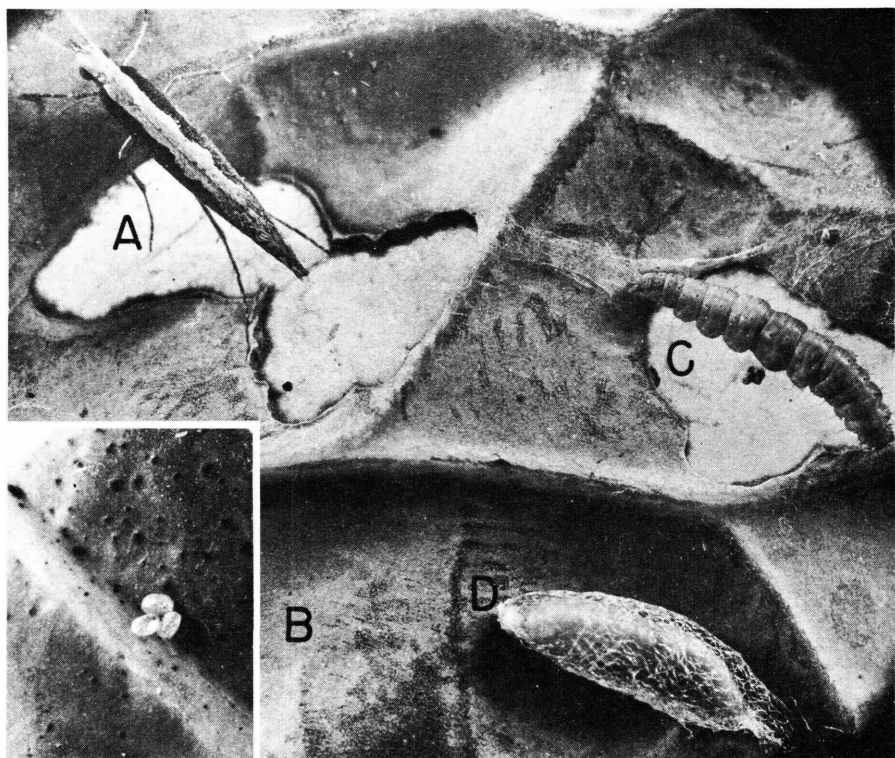
Diamondback moths are about one-third of an inch (0.84 cm) long, have a wingspread of less than an inch (2.5 cm), and are gray (fig. 5). The males have three light-yellow, diamond-shaped markings on their wings. The moths move rapidly when disturbed. They fly short distances from plant to plant during the daytime.

The moths lay single eggs or eggs in groups of two or three on the leaves or on the stalk near the terminal bud. The eggs are small,

nearly round, and yellowish-white.

The larvae are light green and slightly pointed at each end. Their bodies are covered with tiny, erect black hairs. When mature, they are about one-third of an inch (0.84 cm) long. They wriggle rapidly when disturbed, often dropping from the plant and hanging by silk-like threads.

The larvae feed on all parts of the plant, but prefer places around the bud of a young plant, crevices between loose leaves of a firm head, and the underside of lower leaves (fig. 6). Their feeding may disfigure

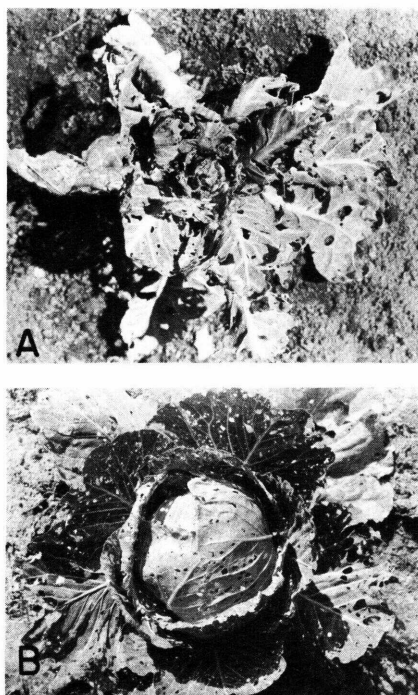


TC-7013, TC-7014

Figure 5.—The diamondback moth: A, Female moth with wings folded. B, Eggs. C, Larva. D, Pupa.

the bud of a young plant so that the head or other marketable portion will not develop properly. Light infestations, especially on broccoli and cauliflower, may not require treatment with pesticides because most damage will be confined to the outer leaves, which are not a part of the marketable product.

The light tan, $\frac{1}{4}$ -inch-long (0.6 cm) pupae are encased in loosely woven, gauzelike cocoons that are fastened to the leaves of the host plant or in crevices near the plant bud.



TC-7253, TC-7254

Figure 6.—Injury caused by larvae of the diamondback moth: A, Young cabbage plant with badly injured bud. B, Typical injury to an older plant.

Cabbage Webworm

The cabbage webworm is the larva of a moth that has front wings of brownish yellow mottled with darker brown, and hind wings of pale gray (fig. 7). The moths have a wingspread that is little more than one-half inch (1.3 cm) long. When



TC-7016

Figure 7.—Cabbage webworms, approximately full grown.

disturbed in the field, the moths make short, uneven flights, and come to rest quickly among the leaves of a plant or on the ground, where their color blends with that of the soil.

The moths lay grayish-white eggs near the buds of young host plants. As the plants mature, the moths begin to lay their eggs on the underside of a leaf in the angle along the leaf stems.

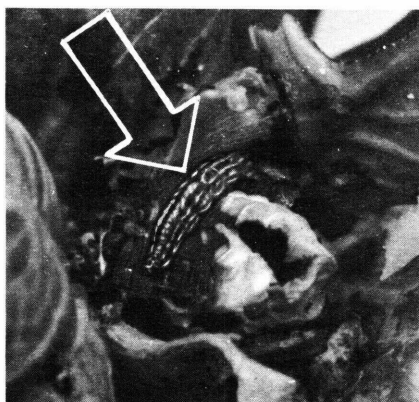
The webworms are about one-half inch (1.3 cm) long when mature. They are dull grayish yellow, and marked with five conspicuous brownish-purple lengthwise stripes. Their heads are black and bear a V-shaped mark.

When first hatched, the larvae feed on either side of the partly folded leaves of the plant buds (fig. 8). After a few days, the larvae begin to feed beneath a protecting web made from silklike threads that they secrete. Sometimes the larvae are found on the outer leaves or along the main ribs of leaves and along the main plant stalk in a leaf

axil. They can be detected by the debris and the webs at the point of feeding.

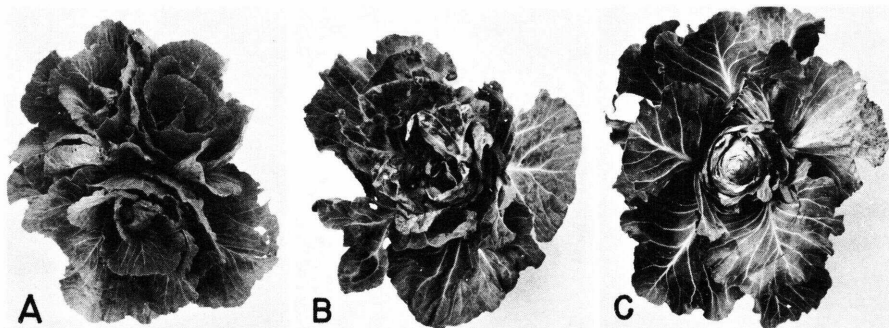
The shiny, light brown pupae are about one-quarter inch (0.6 cm) long. They are formed in a web that is attached to fallen leaves and other debris on the soil surface.

Cabbage webworms tunnel into and kill the buds of young plants of cabbage and related crops. One webworm can ruin a young plant. Destruction of the original bud causes the production of secondary buds that rarely mature by harvest-time (fig. 9). Less severe injury may disfigure the head produced from the original bud. Feeding of this insect on the outer leaves of older plants usually does little harm.



TC-7017

Figure 8.—Cabbage webworm feeding on the bud of a young cabbage plant. To show it, the web was removed and the leaves were partly unfolded.

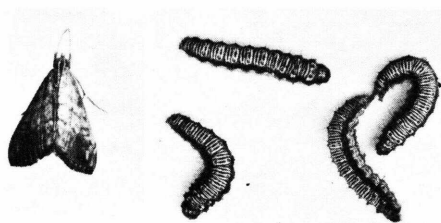


TC-7018, TC-7020, TC-7019

Figure 9.—Cabbage webworm injury to cabbage plants: A, Multibudded plants resulting from earlier destruction of the terminal bud. B and C, Plants with disfigured buds caused by earlier feeding by webworm.

Cross-striped Cabbageworm

The moth of the cross-striped cabbageworm has a wingspread of about 1 inch (2.54 cm). The front wings are mottled yellowish brown to brown, and are marked with zigzag lines of dark brown. The hind wings are lighter, being almost transparent at the base, darker at the front, and marked across the



TC-7029, TC-7070

Figure 10.—Adult and larvae of the cross-striped cabbageworm.

free end with a row of five or six small, indistinct dusky spots.

The eggs are laid in masses of 20 to 30 on the undersides of leaves of cole crops. The eggs overlap one another as shingles on a roof. They are light yellow and semitransparent.

When first hatched, the larvae are gray. When full grown, they are about three-fifths of an inch (1.5 cm) long and have numerous tiny black stripes across bluish-gray backs (fig. 10). Along each side of the back is a black stripe and below that, a bright yellow stripe. The

underside of the body is light green, mottled with yellow.

The larvae enter the soil and pupate just below the soil surface in a tight cocoon. The pupae are about one-half inch (1.3 cm) long and light-yellowish brown to dark brown.

Cross-striped cabbageworms prefer the tender terminal buds and the heads of cole crop plants; they riddle them with holes (fig. 11). Because the eggs are laid in clusters, large numbers of the larvae hatch on individual plants scattered over a field.

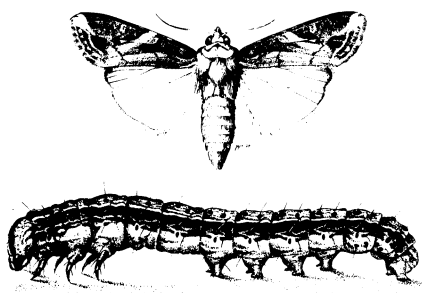


TC-7031

Figure 11.—Cabbage plant injured by the cross-striped cabbageworm. Note that the ends of the leaves are not eaten off and that the holes are smaller.

Fall Armyworm

The fall armyworm is the larva of a night-flying moth that has a wingspread of about 1½ inches (3.8 cm) (fig. 12). The body of the moth



C & F—488

Figure 12.—Adult and larva of the fall armyworm.

is ash gray. The front wings of the male are a mottled dark gray and have an irregular white or light-gray spot near the tip. The front wings of the female are usually darker than those of the male. The hind wings of both sexes are pearly white and are edged with a smokey-brown line.

The eggs are light gray, are covered with a grayish down that comes from the body of the moth, and are laid in clusters of 50 or more, usually on blades of grass.

When first hatched, the larvae are grayish white and have jet-black heads. Full-grown armyworms are about 1½ inches (3.8 cm) long and have dark-gray heads. There are very few hairs on their striped bodies, which range in color from light green to almost black. There is a dark stripe on each side of the body, and a whitish inverted Y marking on the front of the head.

The pupae are shiny, reddish to almost black, and about three-quarters of an inch (1.9 cm) long.

They are found in cells 2 to 6 inches (5 to 15 cm) underground.

Usually only small plants are attacked by the armyworm in fall. The injury is similar to that caused by the cabbage looper.

Corn Earworm

The corn earworm is also known as the tomato fruitworm or the cotton bollworm. It is the larva of a night-flying moth that has a wingspread of about 1½ inches (3.8 cm). The moths vary in color from light olive green to grayish brown or yellowish brown.

The moths lay their eggs on the leaves of the cole crops or on grasses nearby. The eggs are shaped like a flattened ball, ribbed, and are light yellow to dusky brown.

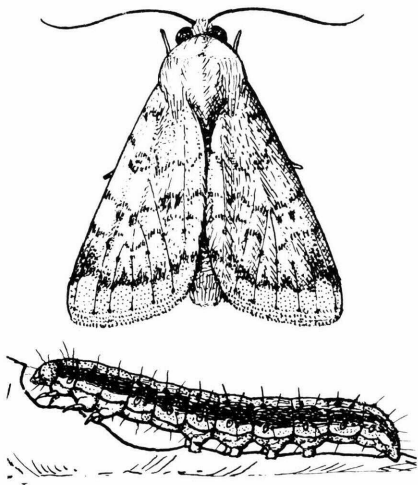
Newly hatched earworms are whitish and have black heads. Older larvae are green, greenish brown, greenish black, or brick colored with yellow, brown, green, and black stripes (fig. 13). Their heads are yellow. Mature earworm larvae are about 1½ inches (3.8 cm) long.

The mature larvae burrow from 2 to 6 inches (5 to 15 cm) into the soil and then transform into shiny, light-brown pupae about three-fourths of an inch (1.9 cm) long.

A single earworm may seriously damage or destroy the bud of a cole crop plant, causing the plant to be disfigured or to produce several secondary buds. Earworms may disfigure the heads of cabbage plants by their feeding and tunneling (fig. 14).

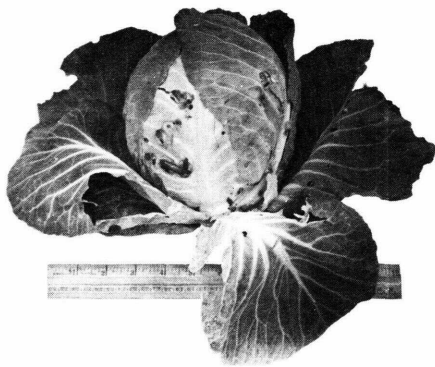
Cutworms

Several species of cutworms, including the black, the variegated, and the granulate attack cole crops.



TC-3851

Figure 13.—Adult and larva of the corn earworm.



TC-7036

Figure 14.—Cabbage head damaged by the corn earworm.

Cutworms are the larvae of night-flying moths. The moths range in color from gray to brown and have varied designs of stripes and spots. They have a wingspan of about 1½ inches (3.8 cm).

The moths lay their eggs on the leaves of grasses, weeds, and other host plants, and sometimes on the bare ground.

Cutworms are smooth-skinned and somewhat shiny. They range

from gray to brown to black. Some of them have distinctive stripes and spots.

The shiny brown pupae are about three-quarters of an inch (1.9 cm) long. They are found underground.

Cutworms feed mostly at night and hide during the daytime on or just below the soil surface. They cut off the stalks of young plants and feed on the leaves, buds, and heads (fig. 15).



TC-2935

Figure 15.—Young cabbage plant whose stalk and leaves were cut off by a cutworm.

Bertha Armyworm

The bertha armyworm is the larva of a night-flying moth that has a wingspread of about 1¼ inches (3.4 cm). The front wings of this brown moth have a broad olive band bordered on the inside by a whitish band.

The moth lays its white, brown-spotted eggs in groups of 100 to 400 on the undersides of leaves. Individual eggs appear to be five-sided because they are laid so closely together.

When first hatched and until they become full-grown, the larvae usually are green with pale to brown heads and appear and act like cabbage looper larvae. Full-grown larvae are about 1¼ inches (3.4 cm) long. The tops of their bodies are black, and the sides are olive green to gray or brown. On each side of the body there is a narrow white stripe, and below the stripe a broad orange to brown band.

The pupae are shiny, dark-chestnut brown, and about three-quarters of an inch (1.9 cm) long. They can be found 2 to 6 inches (5 to 15 cm) underground.

Young bertha armyworms feed at night on cabbage leaves or seedlings, and during the day hide among debris or vegetation. The older armyworms feed during the day or night. They eat the heads and all above-ground portions of the plants, and even inside the stems.

Southern Cabbageworm

The southern cabbageworm is the larva of a white butterfly. The butterfly is similar in appearance to the

imported cabbageworm butterfly, except that it has more checkered black spots on its wings.

The color of the 1-inch-long (2.54 cm) larvae may be bluish, purplish, or green. Their bodies are marked with four lengthwise yellow stripes, and with small black dots (fig. 16).

The pupae are bluish green and spotted. Their appearance and placement is similar to that of the imported cabbageworm.

The injury to cabbage is similar to that caused by the imported cabbageworm.

Gulf White Cabbageworm

The gulf white cabbageworm is the larva of a white butterfly. The butterfly has a wingspread of 2 to 2½ inches (5 to 6 cm) and it also is similar in appearance to the imported cabbageworm butterfly.

The larvae are 1½ inches (3.8 cm) long when mature. They are yellow and marked with four dark green or purplish lengthwise stripes.

The injury to cabbage and related crops is similar to that caused by the imported cabbageworm.

Saltmarsh Caterpillar

Saltmarsh caterpillars are the larvae of a white moth that has yellow and black markings on the body and black dots on the wings (fig. 17).

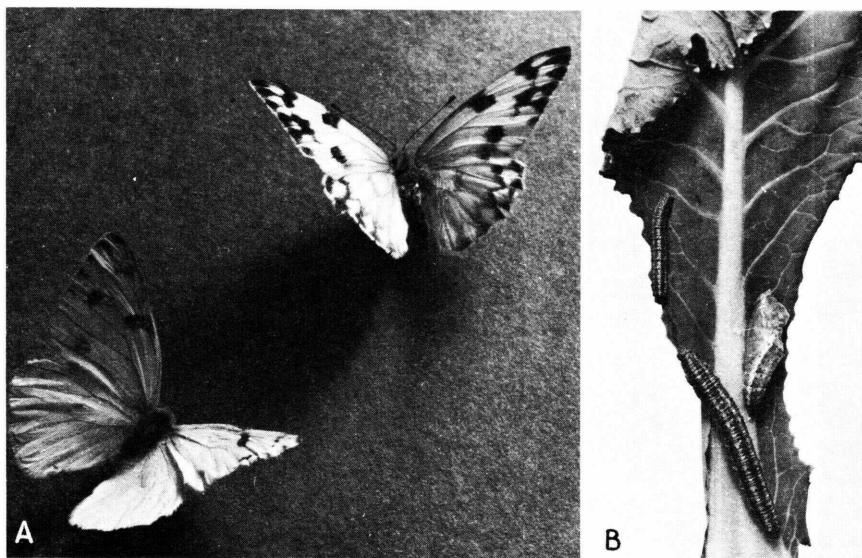
These larvae belong to a group of insects known as woolly bear caterpillars. They are from 1½ to 2 inches (3.8 to 5.0 cm) long when fully grown. Their bodies are partly covered by long reddish-brown

hairs that give them a woolly appearance.

The dark brown pupae are found under trash, dead leaves, and other shelter on top of the soil. They are encased in thin, silken cocoons covered with the interwoven hairs

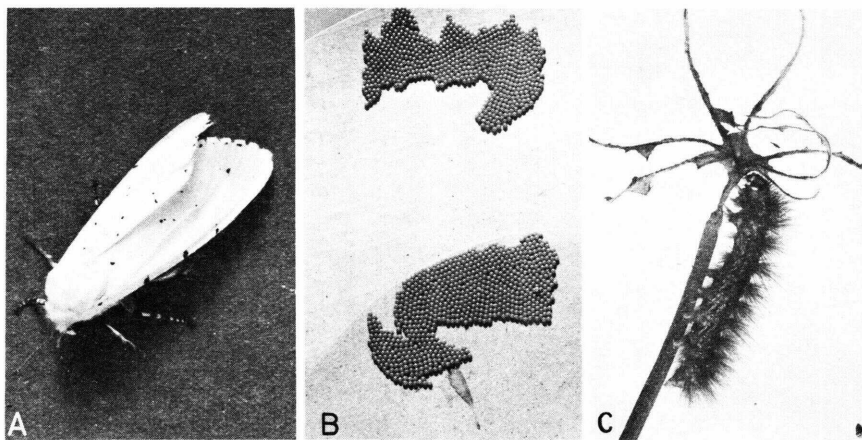
from the body of the caterpillar.

Saltmarsh caterpillars feed on the outer leaves of cole crops, especially on plants near the outer margins of the field. The injury is similar to that caused by the cabbage looper.



TC-7272, TC-7273

Figure 16.—The southern cabbageworm: A, Adults—male (left) and female. B, Larvae and pupa on cabbage leaf.



TC-7274

Figure 17.—The saltmarsh caterpillar: A, Adult female moth. B, Egg masses. C, Caterpillar.

When and Where They Occur

The occurrence and abundance of caterpillars, and the amount of damage they cause to cole crops, is dependent upon the temperature, the length of the growing season, the sequence and variety of crops grown, the availability of alternate host plants (weeds), and, to some extent, the amount of rainfall or the lack of it.

Most caterpillars are not active at temperatures below 50° and 60°F (10° to 15°C). The most severe damage occurs when the temperatures are in the 70s (21°C) and low 80s (27°C).

A given pest may produce from one to three or more generations during a year depending on whether the pest is located in the northern or the southern United States. Generally, a grower may assume that if climate and weather permit the successful production of a crop, then that crop may be attacked by caterpillars, though the degree of attack will vary with the season.

In southern coastal areas, where cole crops are grown throughout the year, the kinds and numbers of caterpillars, as well as the amount of damage they may cause, increase as the growing season progresses from winter to summer. In contrast, relatively fewer worms, in kinds or numbers, are in the Pacific Northwest, and these may not become pests until the edible portions of the crops are formed.

Where the seeding of one to several cole crops occurs, or where the natural occurrence of suitable host plants is spread over the growing season, the earlier crops or weeds form a food reservoir supporting populations that may cause increasingly greater amounts of

damage as the season progresses.

In arid areas, fewer weed hosts are present and this lack of food sources limits development of pest populations. Where particularly heavy rains occur, worms may be injured, drowned, or starved as a result of being washed off the plants.

Winter crops in Florida and southern Texas are injured by imported cabbageworms, cabbage loopers, cabbage webworms, corn earworms, cutworms, and the larvae of the diamondback moth. The larvae of the diamondback moth develop at lower temperatures than most other caterpillars attacking cole crops and are favored by mild, dry winter and spring seasons. The gulf white cabbageworm appears to be a serious pest only in southern Florida, where it is the most common worm on cabbage and collards late in spring and early in summer.

Winter-spring plantings of cole crops in the coastal areas of the Southeast usually are not seriously injured by caterpillars during mid-winter and early spring. Larvae of cabbage loopers, cutworms, and the diamondback moth may be present and can cause considerable damage if the weather is unusually mild. Plantings harvested in April and May, however, are seriously injured by these larvae and those of the imported cabbageworm.

Summer crops in the mid-South mountain areas may be injured by cabbage loopers, imported cabbageworms, cross-striped cabbageworms, and cutworms. Diamondback moth larvae may also injure these plantings, and cabbage webworms and corn earworms may appear late in summer and fall. Directly seeded fall plantings may also suffer injury at least until temperatures are consistently

below 50°F (10°C). Short periods of frost and cold only cause the caterpillars to seek protected places. Cutworms and fall armyworms are especially abundant when grass is grown in a field before cabbage is planted or is allowed to grow with the cole crop.

The cabbage looper is the principal pest in the Pacific Southwest. Though it occurs the year round, it is a serious pest only in mid-September and October. In the milder coastal areas, it may damage cole crops in July and August. The beet armyworm will attack seedlings in the fall. At that time, the armyworm, like the saltmarsh caterpillar, moves from its normal hosts, sugarbeets and cotton, to cole crops. The yellowstriped armyworm has been a serious pest of cole crops in the Pacific Southwest and may be again. Larvae of the imported cabbageworm and the diamondback moth do occur, but are considered to be of little economic importance in that area.

Larvae of the diamondback moth, the most common caterpillars damaging cole crops grown in central California, attack cole crops from early spring through the summer. The next most serious pest is the imported cabbageworm, which occurs year round, but is most damaging during the same spring-summer period. The cabbage looper damages cole crops late in summer and fall, particularly in September and October, when the worms crawl into the heads and feed on them. This infestation of the heads often renders the crop unmarketable. In the fall, the saltmarsh caterpillar may migrate from dry beans and sugarbeets to cole crops. The armyworm may also move to cole crops and feed on young plants and the midribs of

wrapper leaves. The armyworm damages cole crops from August through October.

In the Pacific Northwest, the cole crops are usually grown only from May through October. Major pests in this region are the imported cabbageworm, the diamondback moth, and the cabbage looper. These pests usually cause damage of economic importance only when the heads or other edible portions of the crops are being formed.

The Pacific Northwest can be divided into three agricultural locales: the moist coastal plain, the arid interior, and the intermountain area.

In the moist coastal plain area, some minor feeding occurs on the wrapper leaves and other unmarketable portions of cabbage plants.

In the arid interior area where it is warmer, the number of pests is usually much greater and therefore damage is more common. The bertha armyworm is the most serious pest in this area. In late summer, the bertha armyworm may remove substantial portions of a crop, or contaminate it with wastes.

In the intermountain area, worms rarely injure cole crops severely since both climate and altitude mitigate against their activity and increase in numbers.

In two of the growing areas—the moist coastal plain and the arid interior—the alfalfa and cabbage loopers contaminate cole crops, particularly broccoli and cauliflower.

Chief pests of cole crops in the upper Midwest are the larvae of the cabbage looper, the imported cabbageworm, and the diamondback moth.

The most severe damage is caused by the cabbage looper, which attacks cole crops from early in

August through October. The damage increases and decreases in a 3- to 4-year cycle.

Late in May, the imported cabbageworm moves from wild mustards to cole crops and may be a problem until early in August, when parasitization reduces their numbers to subeconomic levels.

Larvae of the diamondback moth are most damaging in the seed beds during May, although they are also present throughout the rest of the season and may cause significant damage.

The principal cole crop pest in the northeastern Atlantic seaboard is the cabbage looper, which appears late in July and causes the most damage from August to September. As in the upper Midwest its time of appearance and abundance depends on factors affecting its migratory flights (cabbage

loopers do not winter in the northeastern Atlantic seaboard).

The next most serious pest in this area is the imported cabbageworm, which causes the most damage to cole crops during August and September. Diamondback moth larvae are also present in the northeastern Atlantic seaboard throughout the May-September season but are of limited economic importance.

Control With Insecticides

The mere presence of caterpillars on cole crops does not mean that immediate insecticide treatment is necessary. Generally, unless caterpillars are anticipated or are already



PN-6902, PN-6903

Figure 18.—Effect of insecticides in the control of the cabbage looper, the imported cabbageworm, and larvae of the diamondback moth on cabbage. A, Treated plant. B, Untreated plant.

present, the application of insecticides can be delayed until the marketable portions of the crops are formed (fig. 18).

The practice of scheduling treatments to ensure control of pests, whether they are present or not, has been the result of the failure of growers to keep track of the populations of the pests, their selection of the wrong insecticide, their making applications with insufficient volumes or not attaining adequate coverage because of clogged or poorly arranged nozzles or defective or inadequate equipment, or their waiting until the pests have become too large or too numerous.

The treatment of caterpillars on the nonedible or nonmarketed portions of cole crops, or those present during inclement weather or seasons when they are few in number and their potential for causing damage is negligible, is wasteful and potentially harmful to the environment.

Selecting Insecticides

Fields should be examined at least twice a week. If an examination indicates the presence of potentially damaging numbers of larvae, select an insecticide approved for use on the crop to be treated, the locale where it will be applied, and against the specific caterpillar infesting the field.

Because of the complexity of Federal regulations, the variation in effectiveness caused by geography, climate, insect variety or stage of development, and the occurrence of insecticide registrations restricted to specific States or areas, it is difficult to specify insecticidal programs for the control of caterpillars on cole as well as other crops. Each grower should, therefore, consult his or her county agent to discover the treatment appropriate for the pest at hand. Some treatments for major caterpillar pests are suggested in table 1.

Table 1.—Control of the major caterpillar pests on cole crops.

Insect	Description	Insecticide	Active ingredient (1.0 lb/ac = 1.1 kg/ha) lb/acre	Interval between last application and harvest Days	Comments on use
Loopers: Cabbage and alfalfa	Worms pale green with white lines on back and sides. Move in looping manner. Moths gray or brown with silver spot on front wings.	<i>Bacillus thuringiensis</i> (Bactur [®] , Dipel [®] , Thuricide [®]) ¹	See mfg. recommendations	Does not apply.	Treat loopers when infestation rate is one per plant or one- fourth of plants show feeding damage. Not used on kohlrabi.
		Methamidophos (monitor [®]) ^{1 2 3}	0.5 to 1.0	14-21 Broccoli 14 Brussels sprouts 35 Cabbage 28 Cauliflower	Treat every 7 days or more often in hot weather if worms persist.
Imported cabbage- worm	Worms soft velvety green with faint yellow stripes. A white butterfly with black spots.	Methomyl (Lannate [®] , Nudrin [®]) ^{1 2 4}	0.22 to 0.9	3 Broccoli 3 Brussels sprouts 1 Cabbage 3 Cauliflower	
		Azinphosmethyl (Guthion [®]) ^{1 2 3}	0.75	15 Broccoli 7 Brussels sprouts 21 Cabbage 15 Cauliflower	The insecticides listed here and below may control only the smaller loopers. They also may be used against the im- ported cabbageworm and lar- vae of the diamondback moth.
Diamondback moth	Small, pale yellowish- green larvae with erect black hairs. Adults small gray or brown moths with white marks on front wings which form a diamond when the wings are folded.	Carbaryl (Sevin [®]) ^{1 3 5}	1.0 to 2.0	3 Broccoli 3 Brussels sprouts 3 Cabbage 3 Cauliflower 3 Chinese cabbage 14 Collards 14 Kale 3 Kohlrabi	

Diazinon (Spectracide®) ^{1 3 5}	0.5	5 Broccoli 7 Brussels sprouts 7 Cabbage 5 Cauliflower 10 Collards 10 Kale
Endosulfan (Thiodan® , Malix®) ^{1 4 5 6}	1.0	7 Broccoli 14 Brussels sprouts 7 Cabbage 14 Cauliflower 21 Collards 21 Kale
Malathion (Cythion®) ^{1 3 5}	1.25 to 2.5	3 Broccoli 7 Brussels sprouts 7 Cabbage 7 Cauliflower 7 Collards 7 Kale
Methoxychlor (Chemfoam® Marlate®) ^{1 5}	5.0	14 Broccoli 14 Brussels sprouts 3 Cabbage 7 Cauliflower 14 Collards 14 Kale 7 Kohlrabi
Mevinphos (Phosdrin®) ^{1 2 3 9}	0.25 to 0.5	1 Broccoli 3 Brussels sprouts 1 Cabbage 3 Cauliflower 3 Collards 3 Kale
Naled (Dibrom®) ^{1 3 5 9}	1.0 to 2.0	1 Broccoli 1 Brussels sprouts 1 Cabbage 1 Cauliflower 4 Collards 4 Kale

(Refer to footnotes at end of table.)

Table 1.—Continued.

Insect	Description	Insecticide	Active ingredient (1.0 lb/ac = 1.1 kg/ha) lb/acre	Interval between last application and harvest Days	Comments on use
		Parathion ethyl ^{1 2 3 7 8 9}	0.5	7 Broccoli 7 Brussels sprouts 10 Cabbage 7 Cauliflower 10 Collards 10 Kale 10 Kohlrabi	
		Toxaphene ^{1 4 6}	1.5 to 4.0	30 Broccoli 30 Brussels sprouts, cabbage 30 Cauliflower 28-35 Collards 28-35 Kale 30 Kohlrabi	Do not apply this insecticide after the edible parts of plants begin to form.

¹ A wetting or sticking agent may be required for high-volume wettable powder sprays.

² Do not use this extremely poisonous product in the home garden. It should be applied only by a licensed applicator.

³ This product is highly toxic to bees exposed to direct treatment or residues on crops.

⁴ This product should not be applied when bees are actively visiting the crop area.

⁵ Suggested for home garden use.

⁶ Plants treated with this product should not be fed to dairy animals being finished for slaughter.

⁷ Do not harvest for 17 days after treatment if maximum daily temperatures after application are below 70°F (21°C).

⁸ When applied to soil for cutworms, add 2½ pints (1.1 l) of toxaphene per acre. Mixtures of toxaphene with parathion, or of endosulfan with parathion, should provide the recommended dosages per acre of their active ingredients in the mixture. To reduce the danger of injury to plants, use only wettable powder formulations of parathion in low-gallonage sprays containing an emulsifiable concentrate of toxaphene.

⁹ This product may have reduced effectiveness at temperatures below 70°F (21°C). Choose another product to ensure an adequate degree of control.

Applying Insecticides

Insecticides may be applied by spraying or dusting. Currently few are applied as dusts, partly because of the lack of equipment and dust formulations, and partly because of the inherent hazard of excessive drift imposed by the use of dusts. Therefore, a discussion of the application of dusts has not been included, though most of the comments about spraying apply to dusting as well.

Sprays do not adhere well to plants that are wet with rain or dew. Do not spray just before a rain is expected. It may be necessary to spray again if one-half inch (1.3 cm) or more of rain falls within 24 hours after an application.

Sprayers of the type that have an agitator and pump operated with a hand lever are suitable for use in market gardens (fig. 19). But high- or low-volume, power takeoff, self-

contained, or self-propelled sprayers are more suitable for large commercial plantings (fig. 20). If the acreage is sufficiently large, the insecticide may be applied by air. Application by aircraft is particularly advantageous when the soil is too wet to use ground equipment, when the plants are large and cover the surface of the soil, or when a large acreage must be treated quickly.

Adjust the nozzles of spraying equipment so as to direct the insecticide into all parts of the plant and onto both the upper and lower sides of the leaves. Be sure to get good coverage of the growing buds and the marketable portions of the plants.

The amount of spray for control of caterpillars on cole crops may be increased from 20 to 100 gallons per acre (30 to 152 L/ha) to compensate for the amount of foliage present and to ensure adequate



PN-6904, PN-6905

Figure 19.—Equipment suitable for use in small gardens: A, Rotary hand duster. B, Knapsack compressed air sprayer.



PN-6906

Figure 20.—Tractor-mounted hydraulic sprayer suitable for applying an insecticide for control of caterpillars.

coverage. Emulsifiable concentrates are more convenient than wettable powders when spraying in small amounts, but they are more likely to injure the plants. The wettable powder or emulsifiable concentrate should be mixed thoroughly with the water in the spray tank before spraying. It should be kept mixed during the spraying operation.

To reduce drift, use as low a pressure and as high a volume of spray as is feasible. Use equipment designed for your particular crop.

Make sure that the spray reaches the lower as well as the upper surfaces of the leaves. Coverage of the lower surfaces is especially important in the control of loopers or to reach egg masses. Use three or preferably five nozzles per row, especially when the plants are large and loopers are present. Direct the center nozzle downward into tops of plants, and other nozzles into the sides. The side nozzles should be

attached to flexible hoses, placed to give best coverage of the plants. When there are five nozzles per row, the lower pair should be as close to the ground as possible and directed slightly upward.

A single application when the pests are small in size and low in population often permits the use of less toxic and safer-to-handle insecticides and may eliminate the need for more applications of toxic insecticides later in the season. If possible, spray only on warm, calm days. Do not spray when the plants are wilted in the heat of the day, or when wind speeds are more than 5 to 7 mph (8 to 11 km/h), or when it will be necessary to sprinkle irrigate within 48 hours.

As the plants grow larger, you need to increase the volume of the spray to ensure adequate coverage of the foliage. It may also be necessary to increase the pressure of the spray or the speed of the air

carrier to obtain adequate penetration and coverage. Spray-adjuvants such as spreader-stickers may be needed to improve coverage and control the deposit of the insecticide.

Natural Controls

The number of caterpillars that attack cole crops may be reduced appreciably at times by other insects, diseases, spiders, and birds. Usually, however, natural controls will not provide sufficient protection for commercially grown crops. So, they should not be relied upon to control the worms.

Cultural Controls

The following practices help prevent caterpillar injury to cabbage and other cole crops:

- Transplant insect-free spring crops as early as market and weather conditions permit.

- Locate plantings as far as possible from older plants that are infested with caterpillars, especially those infested with larvae of the diamondback moth.

- Harvest the crop as soon as it is ready for market. Then, as soon as possible, dispose of the unmarketable plants or portions by plowing them under or by feeding them to livestock if the insecticide program permits this.

- Seed or transplant in rows of uniform width to permit the effective use of spraying equipment. Space the plants uniformly along the row and far enough apart to prevent crowding. This makes it easier to apply an insecticide to all parts of the plant. Use enough seed to insure an adequate stand, yet not

so much that the young plants will be crowded before they are thinned or transplanted.

- Thin or transplant to a nearly perfect stand of plants with sound terminal buds. Moderate insect injury to the terminal bud often disfigures the plant; severe injury may stop growth of the terminal bud.

- Do not transplant or thin worm-infested plants. Use an insecticide first.

- Provide enough fertilizers, especially the nitrogenous ones, to keep the plants growing vigorously. This will somewhat offset the effects of larval feeding.

Safety Precautions

When used as directed, pesticides are safe and effective; used improperly, they can be injurious to man, animals, and plants. We caution you to read and follow all directions and precautions on pesticide labels. Note particularly what the label says on how to—

- Store pesticides properly.
- Apply pesticides so that they do not endanger humans or livestock.

- Dispose of pesticide containers so that they do not contaminate water or leave illegal residues.

Note all safety precautions that should be taken. For example, you should—

- Keep pesticides out of reach of children.

- Avoid prolonged breathing of pesticide sprays or dust.

- Wear recommended protective clothing and equipment.

- Avoid swallowing, splashing in eyes, or spilling pesticides on parts of the body or clothing.

- Know the appropriate antidote to use, if necessary.

Common and Scientific Names of Caterpillars that Attack Cole Crops

Alfalfa looper	<i>Autographa californica</i>
Armyworm	<i>Pseudaletia unipuncta</i>
Beet armyworm	<i>Spodoptera exigua</i>
Bertha armyworm	<i>Mamestra configurata</i>
Black cutworm	<i>Agrotis ipsilon</i>
Cabbage looper	<i>Trichoplusia ni</i>
Cabbage webworm	<i>Hellula rogatalis</i>
Corn earworm	<i>Heliothis zea</i>
Cross-striped cabbageworm	<i>Evergestis rimosalis</i>
Diamondback moth	<i>Plutella xylostella</i>
Fall armyworm	<i>Spodoptera frugiperda</i>
Granulate cutworm	<i>Feltia subterranea</i>
Gulf white cabbageworm	<i>Ascia monuste</i>
Imported cabbageworm	<i>Pieris rapae</i>
Saltmarsh caterpillar	<i>Estigmene acrea</i>
Southern cabbageworm	<i>Pieris protodice</i>
Variegated cutworm	<i>Peridroma saucia</i>
Yellowstriped armyworm	<i>Spodoptera ornithogalli</i>



Use Pesticides Safely
FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

Issued October 1980